

# OpenFOAM activities at Chalmers and within the Swedish Water Power Center

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Chalmers University of Technology

Applied Mechanics / Fluid Dynamics / CFD

## Outline of the presentation:

- Presentation of SVC  
(the Swedish Water Power Center)
- Presentation of the use of OpenFOAM in the water turbine field, including validation against results from CFX-5 and measurements
- Presentation of other people and activities within SVC using OpenFOAM
- Presentation of other people and activities at Chalmers using OpenFOAM

## SVC – Svenskt VattenkraftCentrum (Swedish Water Power Center, [www.svc.nu](http://www.svc.nu))

Two main parts:

- Civil engineering in water power constructions, LTU/KTH
- Turbines and generators, CTH/LTU/UU

'Turbines and generators' is divided into four parts:

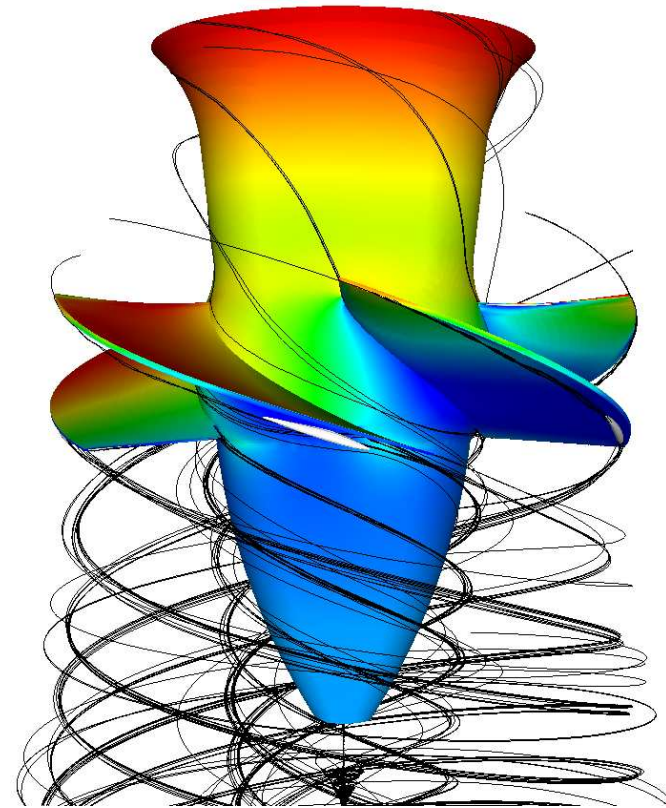
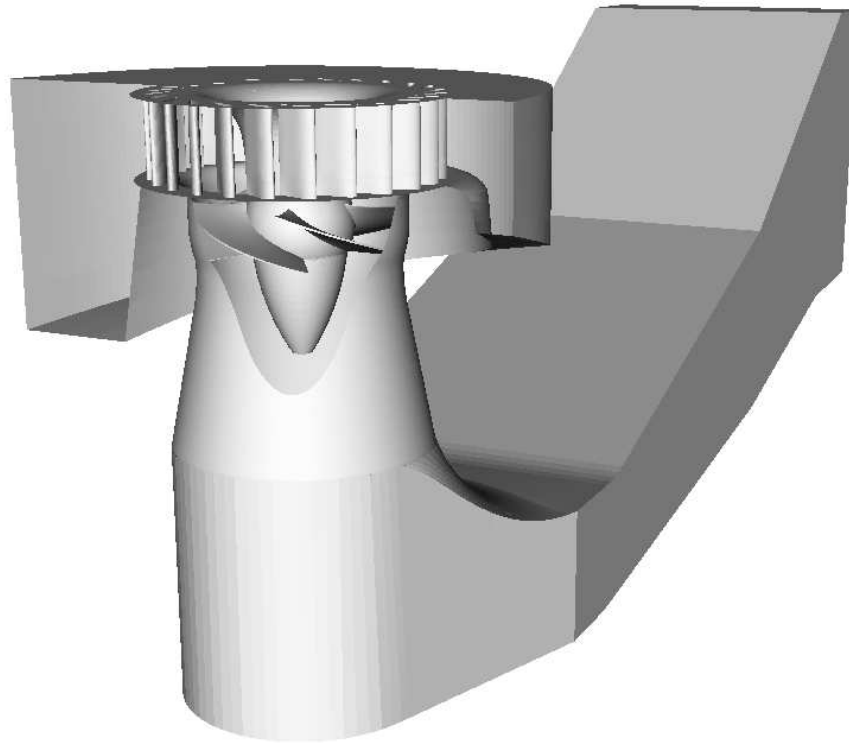
- Tribology (lubrication of bearings), LTU
- Generators, UU
- Rotor dynamics, LTU
- Fluid dynamics, CTH/LTU

Håkan Nilsson is responsible for CFD and OpenFOAM is the tool

Collaboration partners: Swedish Energy Agency, Hydro Power companies<sup>a</sup> (through Elforsk AB), GE Energy (Sweden) AB, Waplans Mekaniska Verkstad AB, Chalmers, LTU, KTH, Uppsala university. (LTH also involved).

<sup>a</sup>Vattenfall AB Vattenkraft, Fortum Generation AB, Sydkraft Vattenkraft AB, Skellefteå Kraft AB, Graninge Kraft AB, Jämtkraft AB, Sollefteåforsens AB, Karlstads Energi AB, Gävle Energi AB, Öresundskraft AB

## OpenFOAM for water turbine applications, and a validation



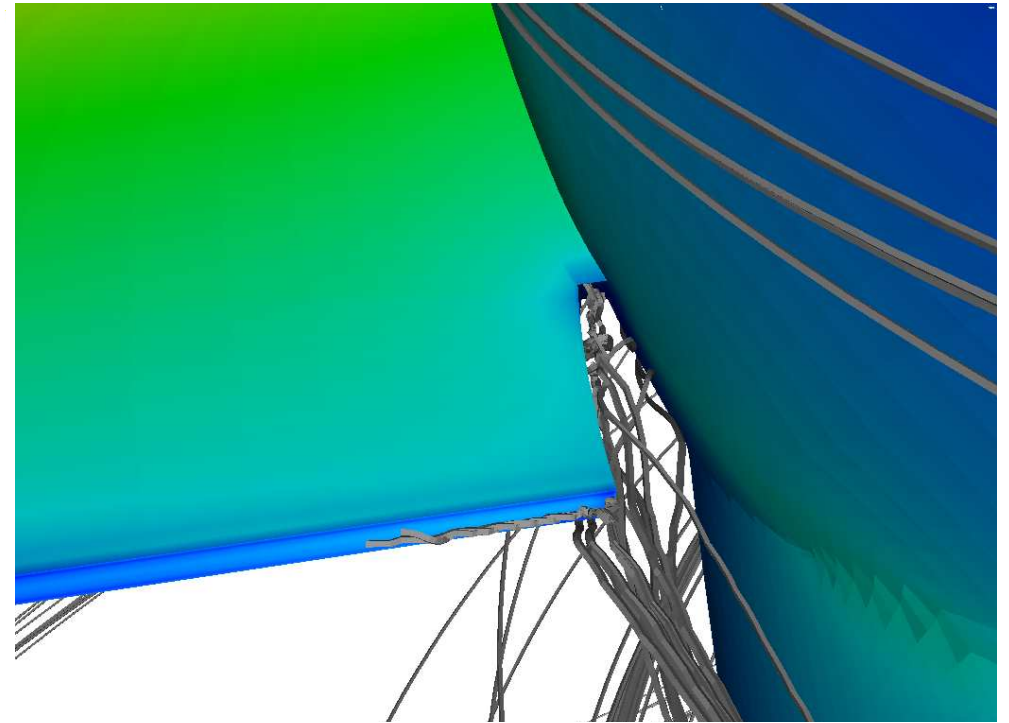
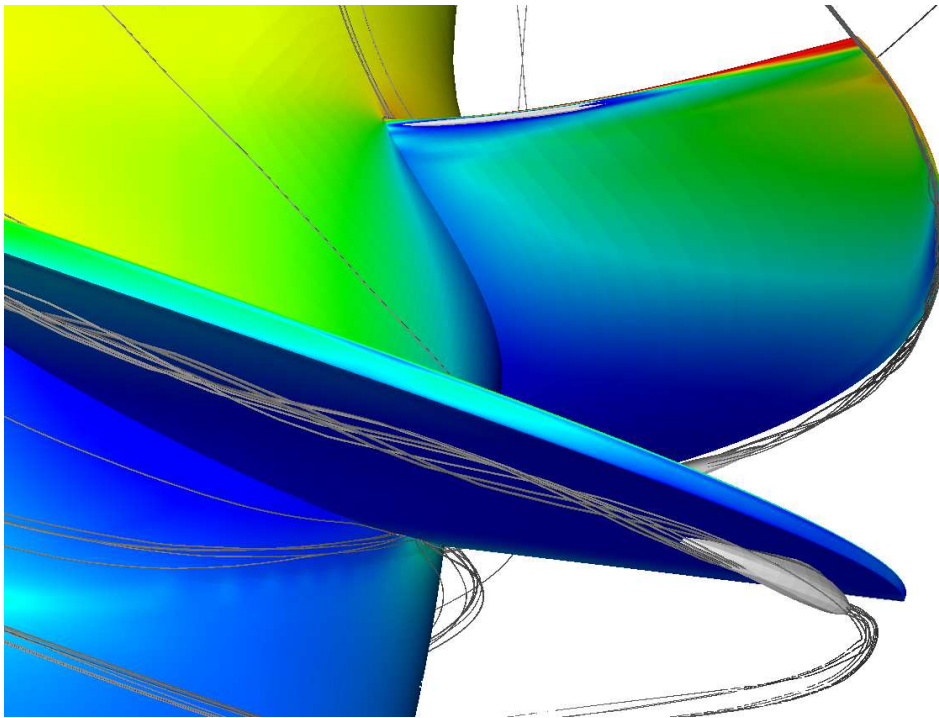
Financed by SVC ([www.svc.nu](http://www.svc.nu)):

Swedish Energy Agency, ELFORSK, Svenska Kraftnät,<sup>a</sup>  
Chalmers, LTU, KTH, UU

<sup>a</sup>Companies involved: CarlBro, E.ON Vattenkraft Sverige, Fortum Generation, Jämtkraft, Jönköping Energi, Mälarenergi, Skellefteå Kraft, Sollefteåforsens, Statoil Lubricants, Sweco VBB, Sweco Energuide, SweMin, Tekniska Verken i Linköping, Vattenfall Research and Development, Vattenfall Vattenkraft, Waplans, VG Power and Öresundskraft

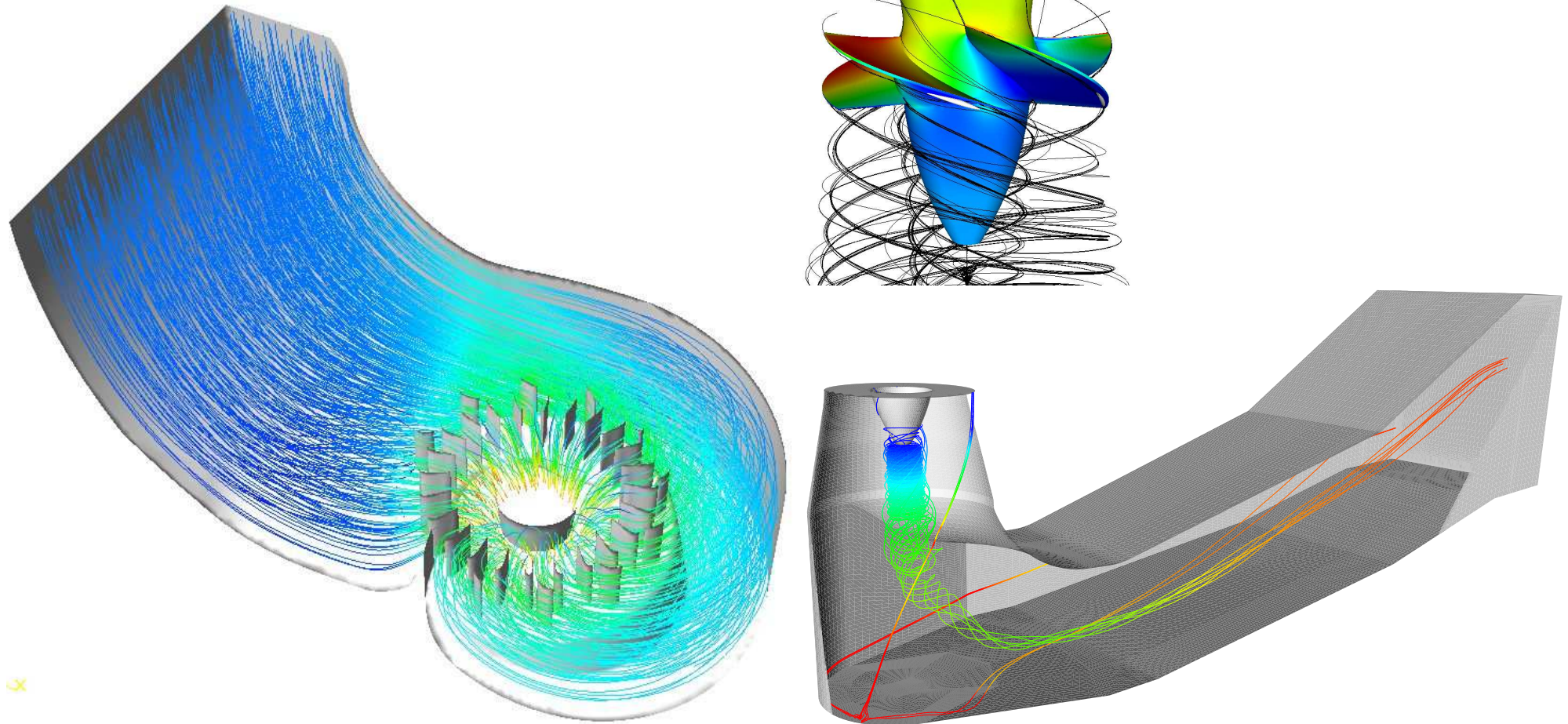
# Runner tip and hub clearances

(small geometrical scales)



## Coupling between flow in different parts of the system

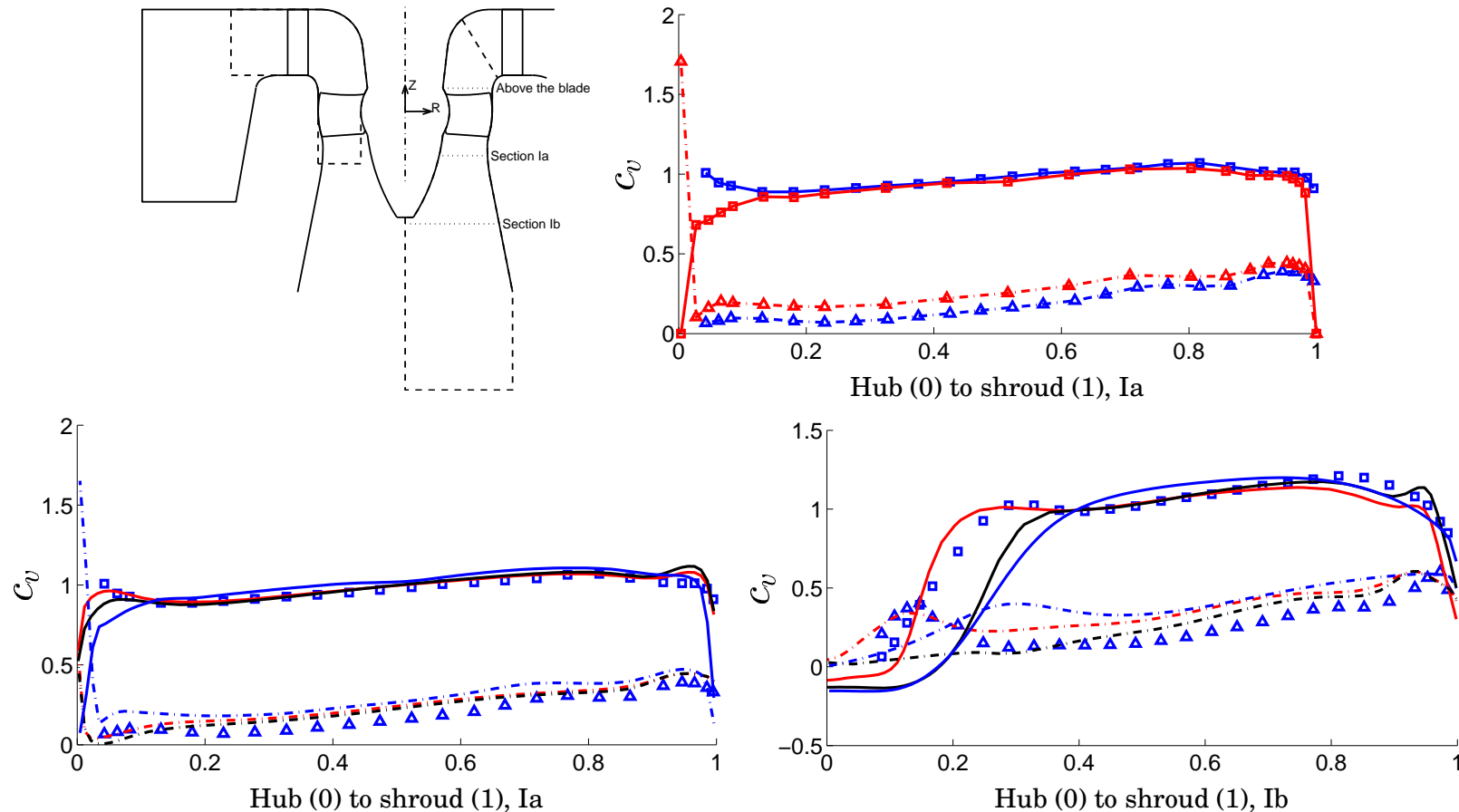
(large geometrical scales)



## Special needs for water turbine applications

- Rotating coordinate systems / multiple frames of reference
- Sliding grid / mixing plane / GGI
- Rotational periodic boundaries (conformal / non-conformal)
- Cavitation models / two phase methods
- Fine resolution in large domains (parallel computations)
- Moving mesh (rotor dynamics)
- Unsteady SIMPLE solvers (skew grids)
- ...

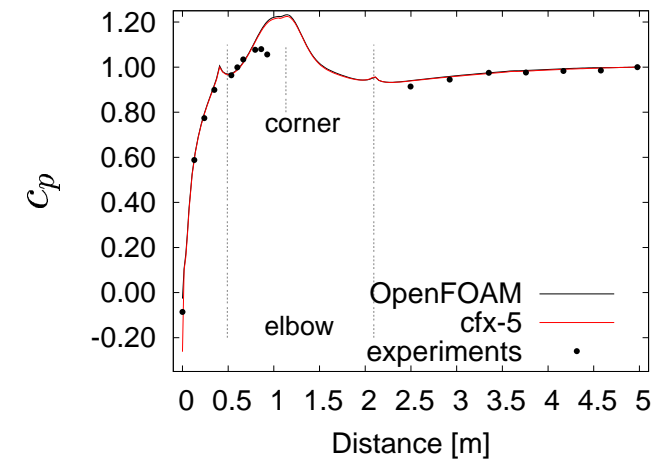
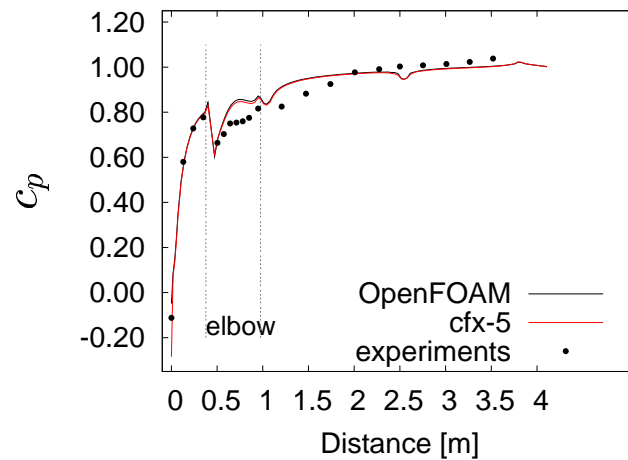
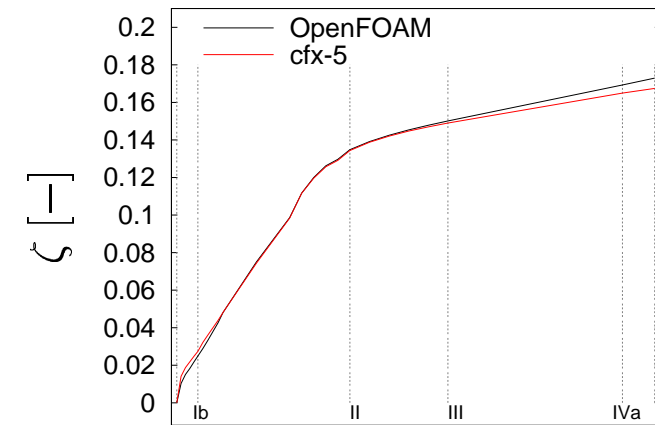
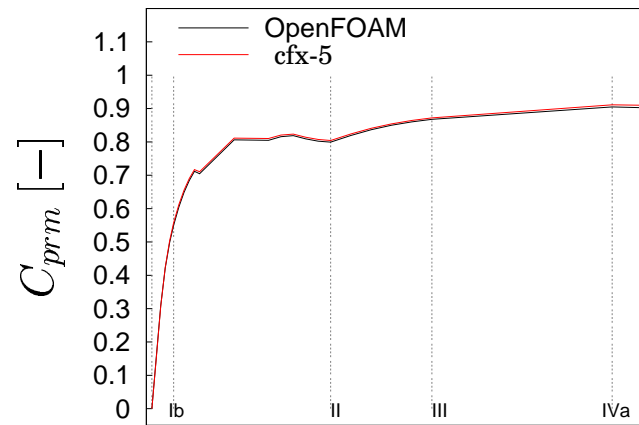
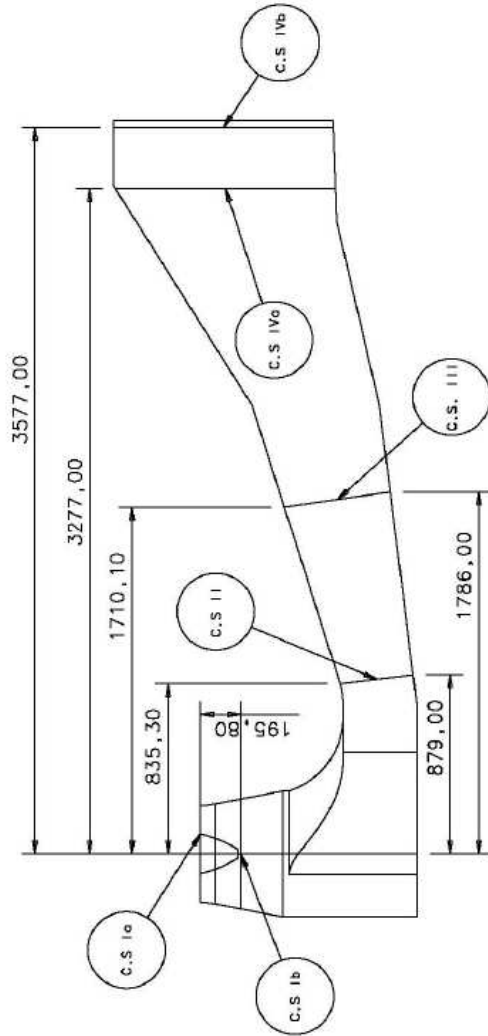
## Validation of OpenFOAM in the Hölleforsen runner (velocity profiles at cross-sections Ia and Ib)



Squares: measured axial velocity. Triangles: measured tangential velocity. In (a) the colors correspond to two different measurements. In (b) and (c): Blue curve: quasi-steady draft tube, Black curve: runner without hub clearance, Red curve: runner with hub clearance.

## Validation of OpenFOAM in the Hölleforsen draft tube (development of engineering quantities in the flow direction)

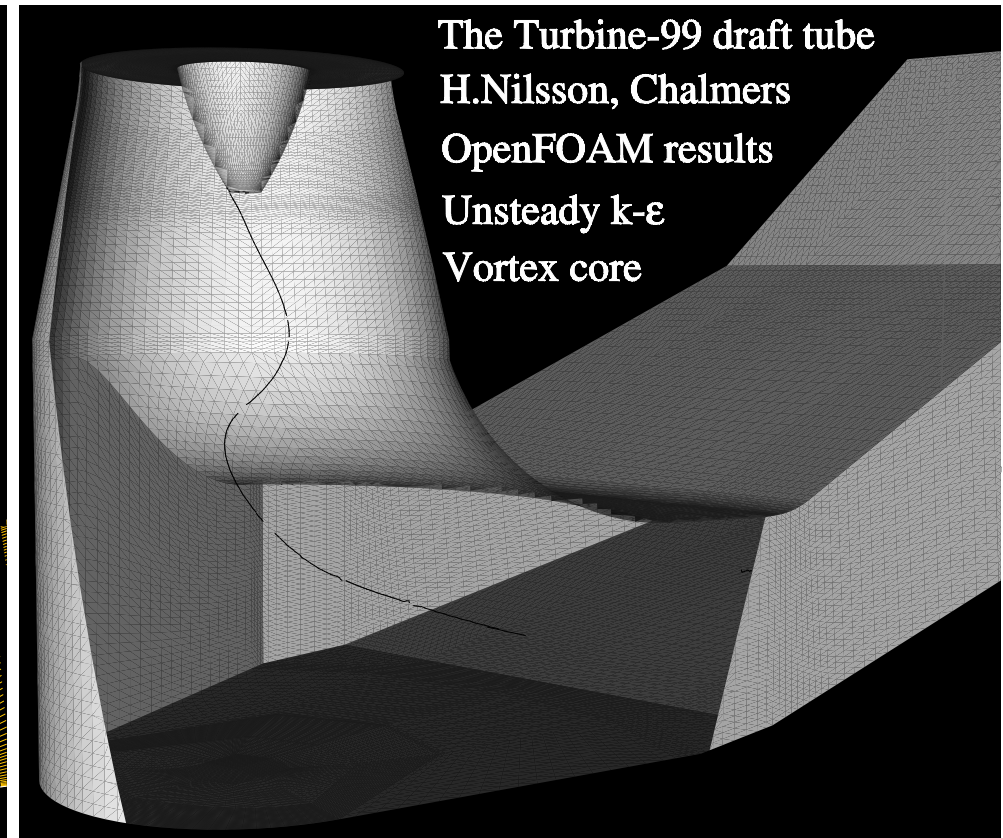
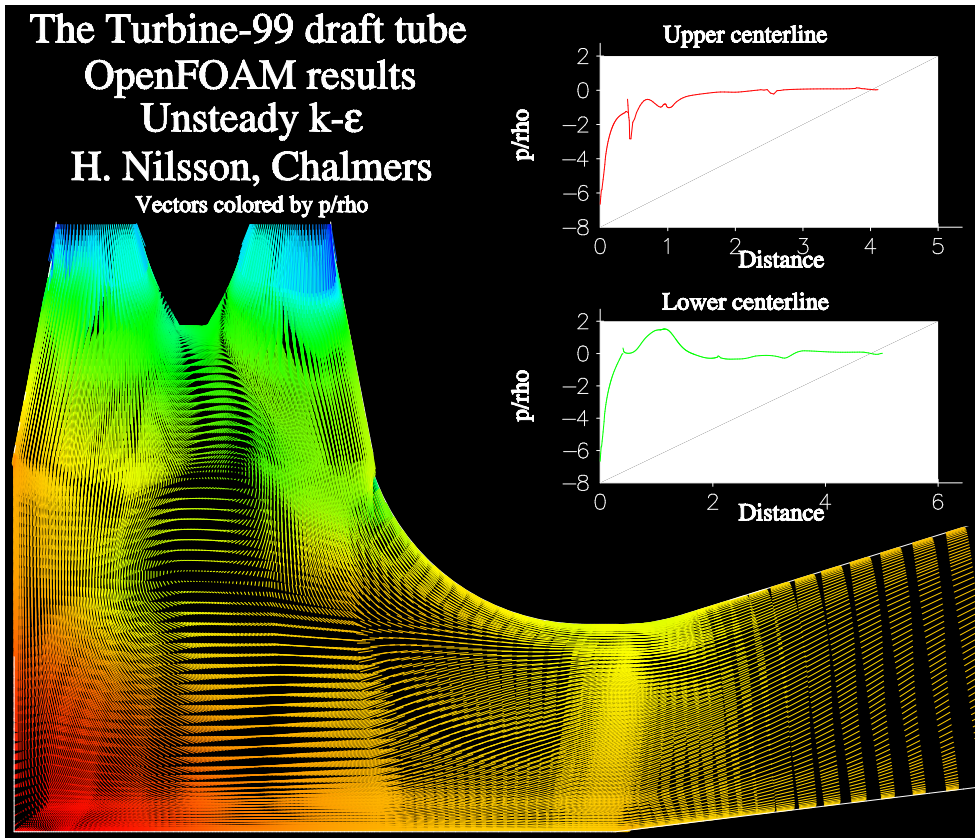
### Quasi-steady draft tube computation





## Vortex rope of the unsteady draft tube computation

Periodicity in time:  $\sim 0.48s$  (same as CFX-5)



## People and projects within SVC using OpenFOAM

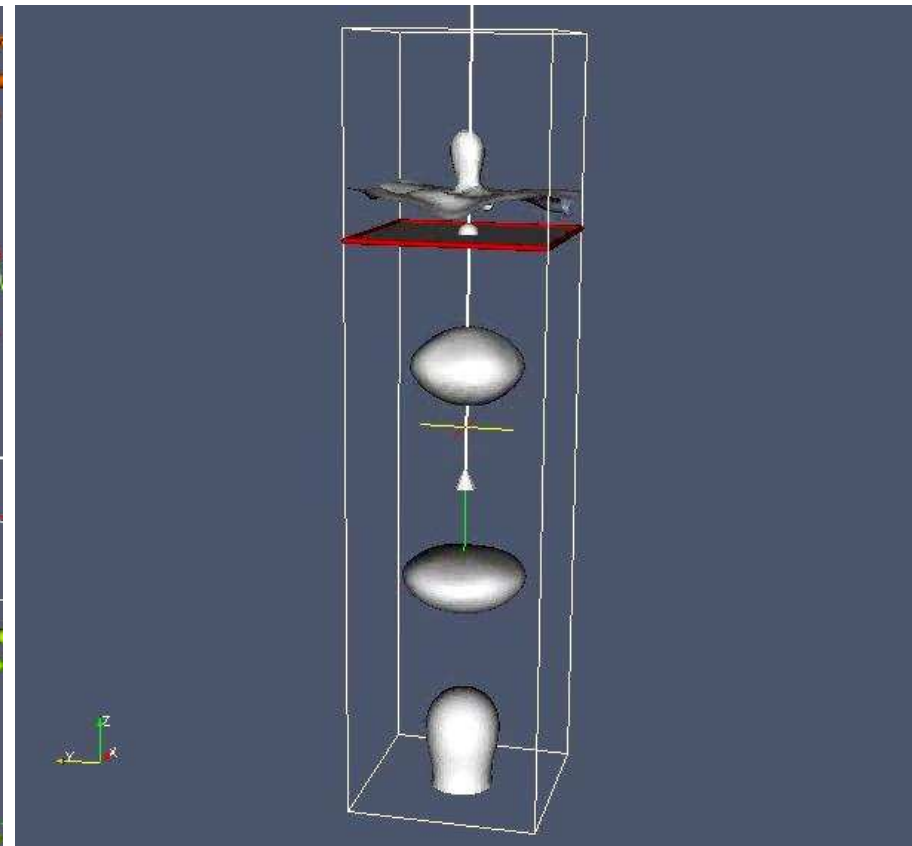
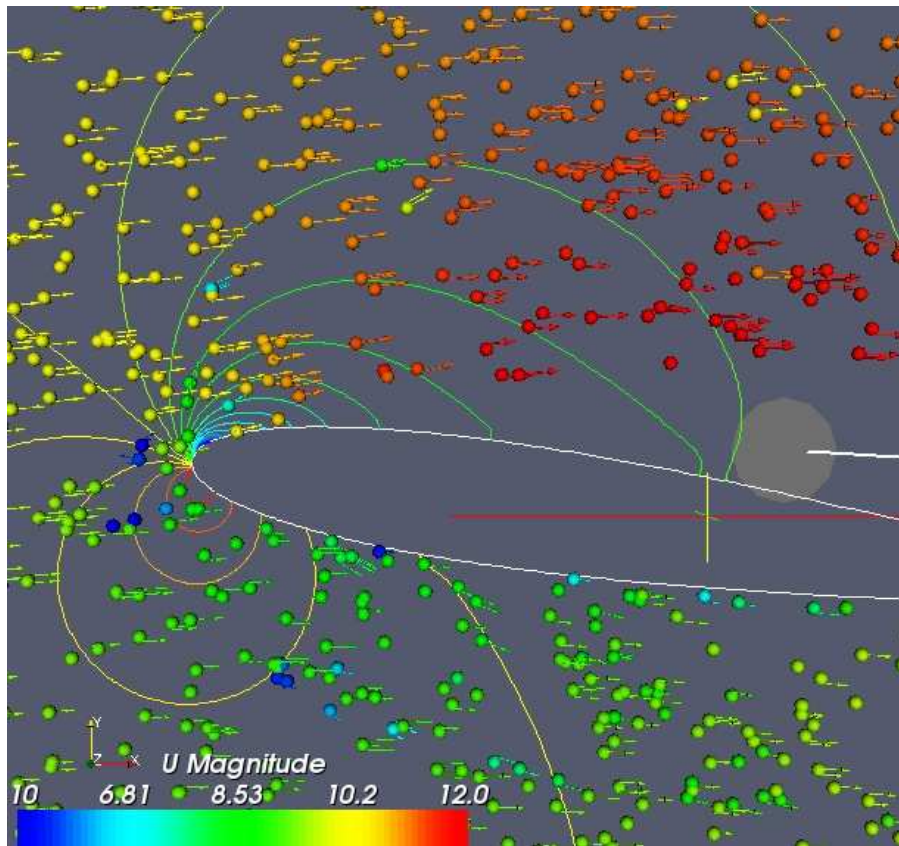
**Aurelia Cure** (LTH, Co-supervised by Håkan Nilsson, Chalmers)

(soon also **Henrik Lindsjö**, WAPLANS, Co-supervised by Håkan Nilsson, Chalmers)

Lagrangian particle tracking at the NACA0015 profile

Rising bubbles using the VOF method

Purpose: Cavitation in water turbines

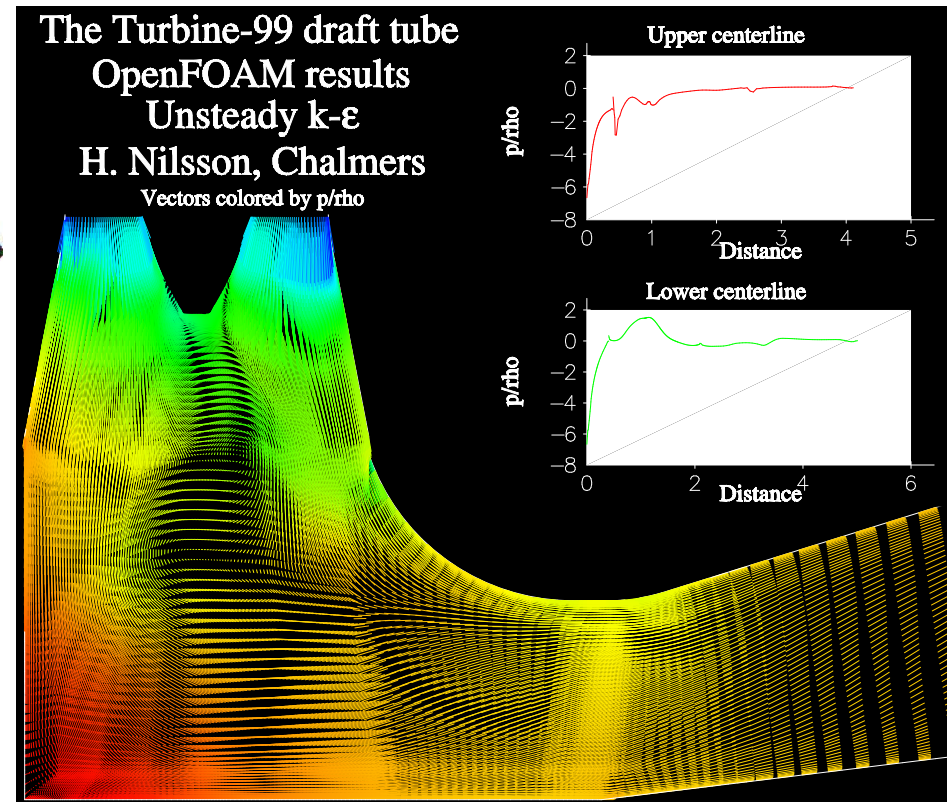
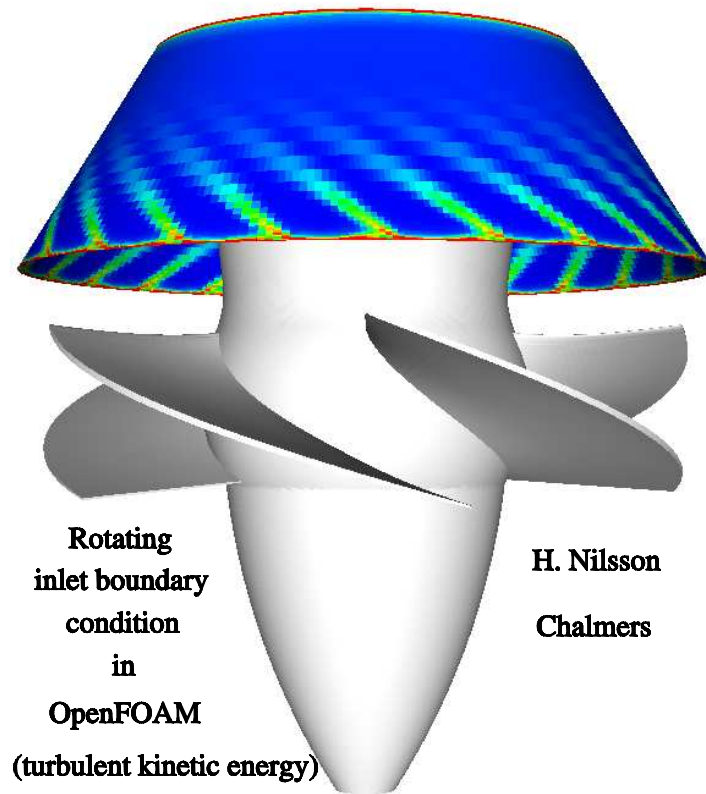


## People and projects within SVC using OpenFOAM

**Martin Karlsson**, LTU, Collaborating with Håkan Nilsson, Chalmers

Rotor dynamics -

non-axisymmetric inlet b.c., varying rotational velocity and moving runner (deforming mesh)



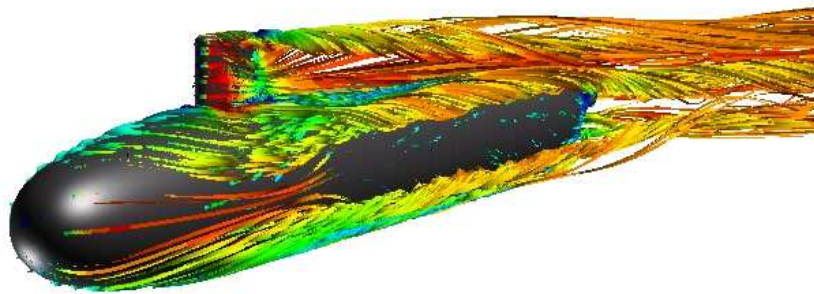
... and two planned ph.D. projects using OpenFOAM for water turbine applications

## People and projects at Chalmers using OpenFOAM

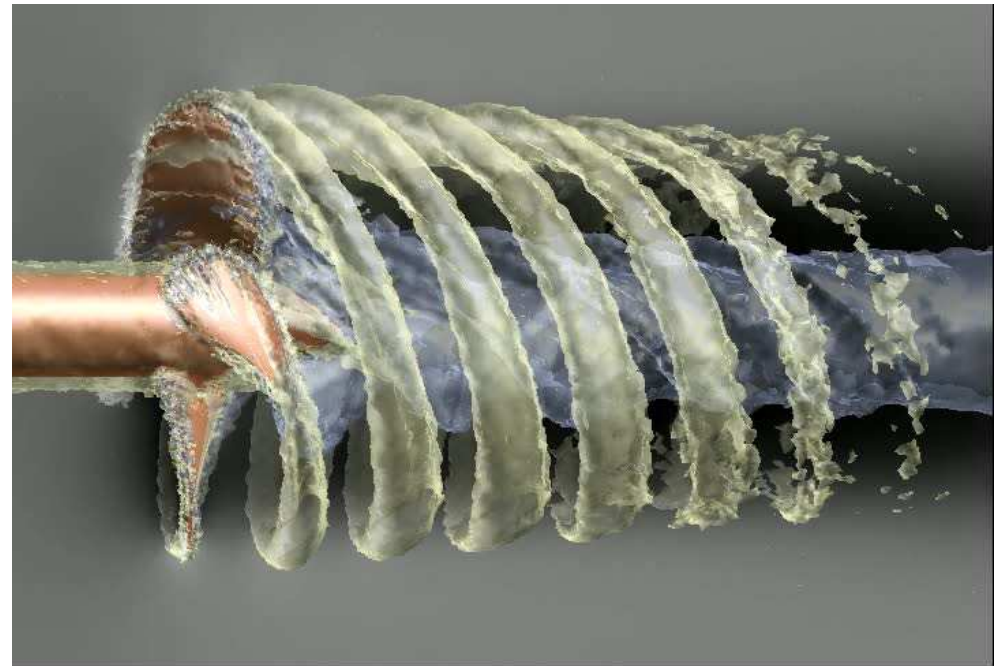
**Rickard Benzow**, Shipping and Marine Technology, Chalmers

LES of a turning submarine

LES of a propeller in a rotating mesh



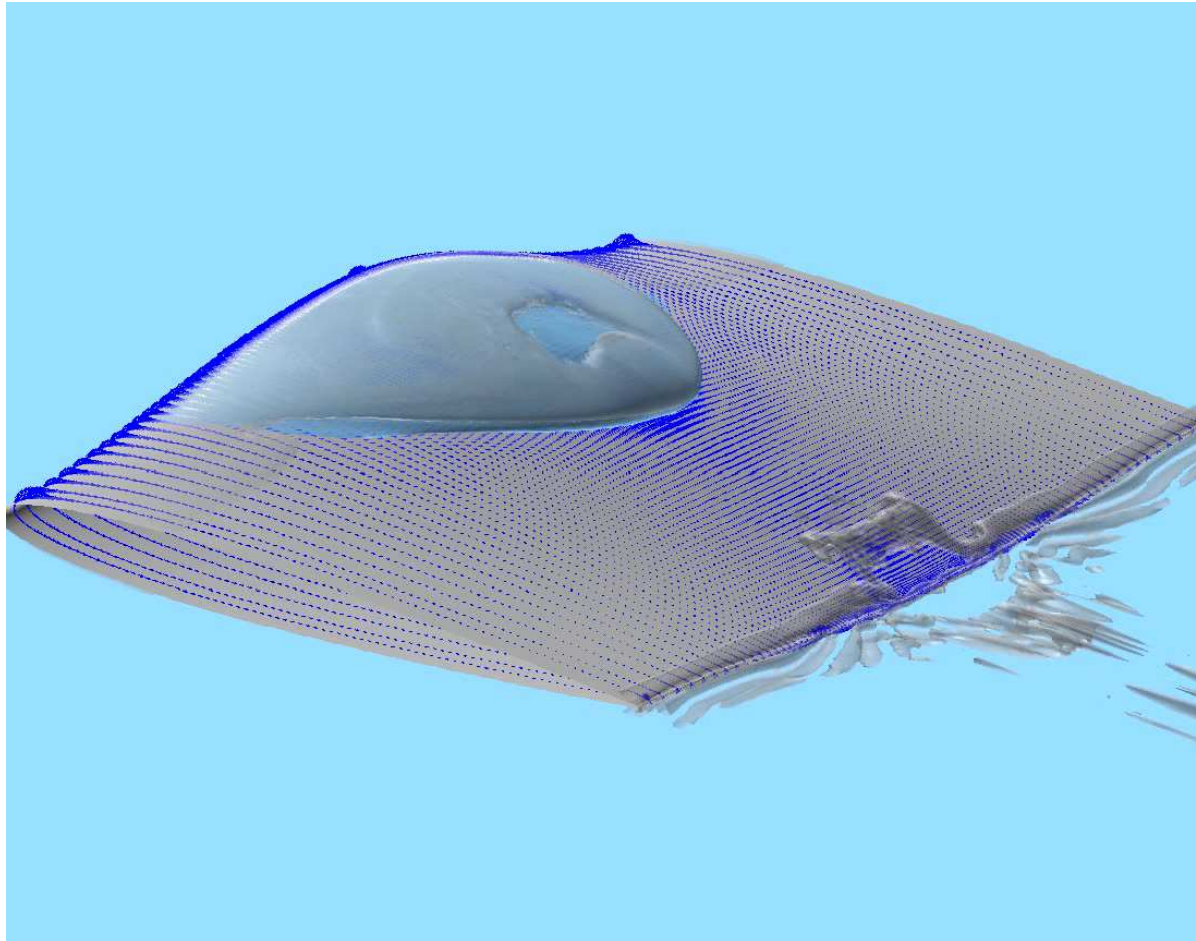
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## People and projects at Chalmers using OpenFOAM

**Tobias Persson**, Shipping and Marine Technology, Chalmers

Cavitation modelling and LES, cavInterFoam (developed by **Niklas Wikström**, FOI/Chalmers)

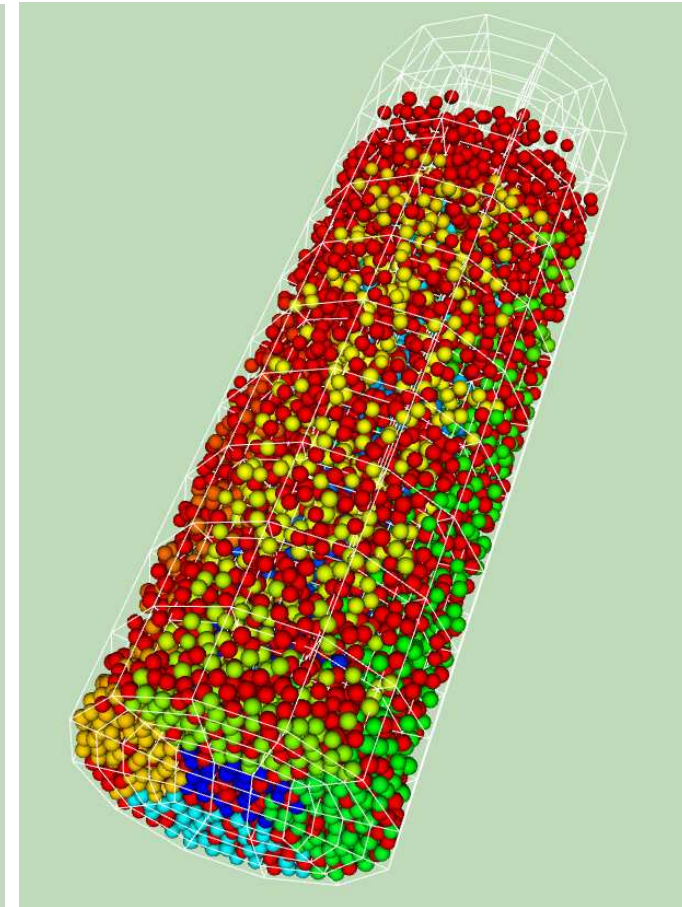
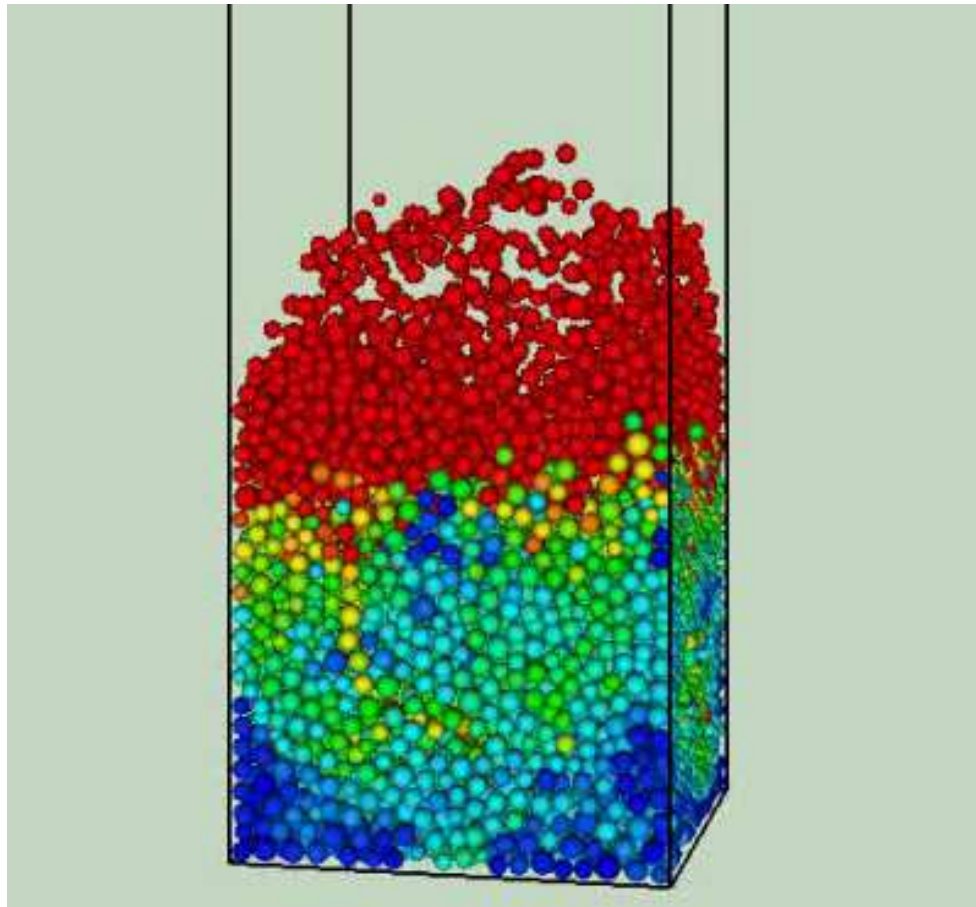


## People and projects at Chalmers using OpenFOAM

**Rasmus Hemph**, Applied Mechanics, Fluid Dynamics, Chalmers

Fluidized beds using Lagrangian Particle Tracking

Column packing using Lagrangian Particle Tracking

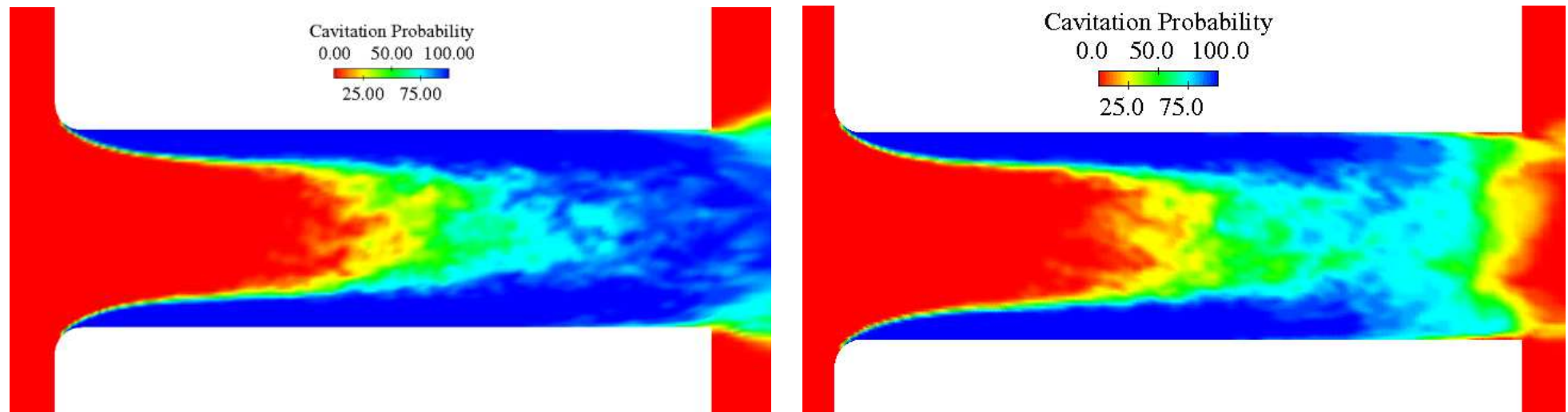


## People and projects at Chalmers using OpenFOAM

**Fabian Peng Kärrholm**, Applied Mechanics, Combustion, Chalmers

Cavitation in diesel nozzles

cavitatingFoam (Now available in OpenFOAM 1.4)



## People and projects at Chalmers using OpenFOAM

**Isabelle Choquet and Margarita Sass-Tisovskaya,**

University West Trollhättan,

in collaboration with Håkan Nilsson and Lars Davidson, Chalmers

Welding in OpenFOAM



Thank you for your attention!

## **Acknowledgements**

The OpenFOAM developers ([www.openfoam.org](http://www.openfoam.org))

Dr. Hrvoje Jasak, Wikki Ltd.

**Håkan Nilsson is partly financed by SVC** ([www.svc.nu](http://www.svc.nu)):

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Chalmers, LTU, KTH, UU

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